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Factors associated with the prevalence of arteriovenous fistulas in hemodialysis patients in the HEMO Study

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Background. Arteriovenous (AV) fistulas are the vascular access of choice for hemodialysis patients, but only about 20% of hemodialysis patients in the United States dialyze with fistulas. There is little information known about the factors associated with this low prevalence of fistulas.

Methods. Multiple logistic regression analysis was used to evaluate the independent contribution of factors associated with AV fistula use among patients enrolled in the HEMO Study. The analysis was conducted in 1824 patients with fistulas or grafts at 45 dialysis units (15 clinical centers).

Results. Thirty-four percent of the patients had fistulas. The prevalence of fistulas varied markedly from 4 to 77% among the individual dialysis units ($P < 0.001$). Multiple regression analysis revealed five demographic and clinical factors that were each independently associated with a lower likelihood of having a fistula, even after adjustment for dialysis unit. Specifically, the prevalence of fistulas was lower in females than males [adjusted odds ratio (AOR) 0.37, 95% CI, 0.28 to 0.48], lower in patients with peripheral vascular disease than in those without (AOR 0.55, 95% CI, 0.38 to 0.79), lower in blacks than in non-blacks (AOR 0.64, 95% CI, 0.46 to 0.89), lower in obese patients (AOR per 5 kg/m^2 body mass index, 0.76, 95% CI, 0.65 to 0.87), and lower in older patients (AOR per 10 years, 0.85, 95% CI, 0.78 to 0.94). The differences in the prevalence of fistulas among the dialysis units remained statistically significant ($P < 0.001$) after adjustment for these demographic and clinical factors. Finally, there were substantial variations in the prevalence of fistulas even among dialysis units in a single metropolitan area.

Conclusions. Future efforts to increase the prevalence of fistulas in hemodialysis patients should be directed at both hemodialysis units and patient subpopulations with a low fistula prevalence.

Key words: angioaccess, age, race, diabetes, gender, vascular access, chronic renal failure.

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Vascular access procedures and their subsequent complications represent major causes of morbidity, hospitalization, and cost for chronic hemodialysis patients [1–4]. Over 20% of hospitalizations in hemodialysis patients in the United States are access related, and the annual cost of access morbidity has been estimated at close to $1 billion [4]. Polytetrafluoroethylene (PTFE) dialysis grafts have decreased longevity as compared with native arteriovenous (AV) fistulas [5–8] and are more prone to recurrent stenosis, thrombosis, and infection [9]. Recognizing the superiority of fistulas over grafts, the recently published National Kidney Foundation Dialysis Outcomes Quality Initiative (DOQI) guidelines on vascular access [10] recommend an aggressive approach to the creation of fistulas, with AV grafts being reserved for patients whose vascular anatomy does not permit construction of a native AV fistula. Notwithstanding these national recommendations, only about 20% of hemodialysis patients in the United States have an AV fistula as their vascular access [11]. In fact, the rate of fistula placement in new hemodialysis patients actually decreased between 1986 and 1990 [12].

There is little published information regarding the patient characteristics that determine whether hemodialysis patients receive an AV fistula rather than a graft. Female gender, older age, diabetes mellitus, and peripheral vascular disease have each been associated with a lower frequency of AV fistulas [6, 7, 12–14]. Moreover, geographic region has been identified as a major determinant of fistula incidence within the United States, even after adjustment for multiple demographic and clinical factors [12]. Specifically, the incidence of fistulas among new hemodialysis patients is highest in New England and lowest in the Southeast.

The HEMO Study is an ongoing large, prospective, randomized clinical trial evaluating the effects of Kt/V

and dialyzer flux on patient mortality and morbidity [15]. As of April 1999, over 2000 hemodialysis patients have been enrolled from 15 clinical centers (66 dialysis units) with a wide geographic distribution. The information collected about these patients includes the type of vascular access used for their dialysis. The purpose of the present study was to evaluate the demographic and clinical factors that are associated with the type of vascular access (AV fistula vs. graft) among the patients enrolled in the HEMO Study.

METHODS

Patient population

Hemodialysis patients were recruited into the HEMO Study from 66 hemodialysis units associated with 15 university-affiliated clinical centers. The major inclusion criteria for patient recruitment included ages 18 to 80 and maintenance hemodialysis for at least three months. The major exclusion criteria included severe comorbid conditions associated with life expectancy of less than one year (class IV congestive heart failure, chronic pulmonary disease requiring home oxygen, cirrhosis with encephalopathy or coagulopathy, metastatic cancer, or AIDS), patients scheduled for a living-related kidney transplant, large residual renal function (urea clearance >1.5 mL/min per 35 L of urea volume), and inability or unwillingness to follow the study protocol. Patients enrolled into the baseline (pre-randomization) phase of the HEMO Study served as the population for the current analysis.

Data collection

At the time of initial patient enrollment into the study extensive demographic and clinical information was collected; it included age, sex, race, body mass index (BMI), presence of diabetes mellitus, socioeconomic status (education and income), as well as the type of vascular access that was being used for each patient (AV fistula, AV graft, or temporary dialysis catheter). The type of vascular access was ascertained by the study coordinator at each clinical center by direct inspection and/or review of the operative record. Approximately 70% of the baseline patients were randomized into the full-scale study. Additional information was collected in this subset of patients regarding comorbid illness (including coronary artery disease, congestive heart failure, peripheral vascular disease, and hypertension). An Index of Coexisting Disease (ICED) was developed to score the severity of the comorbid conditions. The severity of each disease (coronary artery disease, congestive heart failure, hypertension, and peripheral vascular disease) was scored as 0 if it was absent, 1 if it was asymptomatic or mildly symptomatic, 2 if it was moderately symptomatic, and 3 if it was severely symptomatic. For the purpose of the current analysis, patients were classified as having a given disease if their severity score was ≥ 2 (this decision was made prior to the statistical analysis). The ICED scores were determined by the study coordinators under the supervision of the principal investigators. The study coordinators were trained in the coding of the ICED prior to the start of the study and annually during the study.

Statistical analysis

During a four-year period from March 1995 to April 1999, a total of 2149 patients were enrolled into the HEMO Study. The 150 patients using dialysis catheters and patients in dialysis units enrolling fewer than 15 subjects were excluded from further analysis. Thus, all statistical analyses were restricted to the 1824 patients dialyzing with either a fistula or graft in the 45 dialysis units having at least 15 study patients. In addition, analyses involving comorbidity had to be restricted to the subset of patients in whom the ICED scores were obtained ($N = 1371$). Moreover, many patients declined to discuss their income, so that particular analysis was restricted to those patients who provided this information ($N = 1402$).

To assess whether clinical centers were associated with variations in the prevalence of fistulas that could not be explained by the other demographic and clinical factors, we tested the significance of the clinical center as a single categorical variable (with 14 degrees of freedom to account for possible differences among the 15 centers) in a joint multiple logistic regression that also included the other demographic and clinical variables. A similar analysis was performed to determine whether the dialysis unit was independently associated with the prevalence of fistulas. Separate univariate logistic regression analyses were used to relate the odds of fistula to each of the identified associated variables in Table 1. These logistic regressions for the individually associated variables were then repeated controlling for dialysis unit. (In all cases, the same number of patients was used to calculate the crude and adjusted analyses.) Stepwise logistic regression was used to identify a set of jointly significant variables associated with lower fistula use. The dialysis unit was treated as a single categorical factor in the stepwise logistic regression. Among patients using fistulas, further logistic regression analyses were used to relate the odds of upper arm placement to the respective associated variables, while controlling for dialysis unit.

RESULTS

The demographic and clinical characteristics of the patient population are summarized in Table 1. The gender distribution and the frequency of diabetes mellitus in this study population were similar to those in the prevalent U.S. hemodialysis population, whereas the proportion of HEMO Study patients with ages ≥ 65 years

Table 1. Baseline patient characteristics

Variables	Values	*N*	%
Gender	Female	937	51.4
	Male	887	48.6
Age[a]	<65 years	1180	64.7
	≥65 years	644	35.3
Race	Non-black	650	35.6
	Black	1174	64.4
BMI	<27 kg/m^2	1212	66.4
	≥27 kg/m^2	612	33.6
CAD[b]	No	845	61.6
	Yes	526	38.4
CHF[b]	No	1224	89.3
	Yes	147	10.7
Diabetes	No	1029	56.4
	Yes	795	43.6
Hypertension[b]	No	314	22.9
	Yes	1057	77.1
PVD[b]	No	1138	83.0
	Yes	233	17.0
Smoker	No	1066	58.4
	Yes	758	41.6
Income[b]	≥$7500 per year	724	51.6
	<$7500 per year	678	48.4
Education	≤HS	1249	68.5
	>HS	575	31.5
ESRD duration	<1 year	484	26.5
	1–5 years	899	49.3
	>5 years	441	24.2

Abbreviations are: CAD, coronary artery disease; PVD, peripheral vascular disease; CHF, congestive heart failure; BMI, body mass index (kg/m^2); HS, high school.

[a] Mean age, 57 ± 14 years

[b] Information regarding comorbid conditions and income was not available for some baseline patients who were not randomized into the full-scale study.

were somewhat lower than for the general dialysis population (35 vs. 43%). The proportion of black patients in the HEMO Study was higher than in the general dialysis population (64 vs. 39%) [16], reflecting the preponderance of black patients among the clinical centers participating in the HEMO Study. The patients enrolled in the HEMO Study had substantial comorbidity, as summarized in Table 1.

Thirty-four percent of the study patients were dialyzing with a fistula, and 66% with a graft. The prevalence of fistulas was strongly associated with both the clinical center ($P < 0.001$) and with the dialysis unit ($P < 0.001$). The variation in fistula prevalence among the dialysis units remained statistically significant after controlling for clinical center ($P = 0.002$), indicating that there was significant variation in fistula prevalence among the dialysis units associated with the same clinical centers. Univariate analysis revealed a significantly lower prevalence of AV fistulas associated with female gender, age ≥65 years, black race, diabetes mellitus, obesity (BMI ≥27 kg/m^2), peripheral vascular disease, coronary artery disease, and annual income <$7500 (Table 2). Each of these associations persisted after adjustment for the dialysis unit. In contrast, hypertension, congestive heart failure, smoking history, patient education, and the duration of dialysis was not associated with fistula prevalence. None of the associations of comorbid conditions with fistula prevalence was changed when the analysis was repeated for all patients with a given comorbid condition, rather than just those with a severity score ≥2. Stepwise logistic regression analysis identified six factors that were independently associated with the prevalence of AV fistulas: dialysis unit, female gender, obesity, peripheral vascular disease, age ≥65 years, and black race (Table 3). The discrepancy between fistula prevalence in blacks and whites occurred in both dialysis units with a high overall proportion of fistulas, as well as in units with a low overall proportion of fistulas. Moreover, a lower prevalence of fistulas in black subjects was observed in both hemodialysis units with a high or low proportion of black subjects.

The clinical center was strongly associated ($P < 0.001$) with fistula prevalence even after adjustment for all other demographic and clinical characteristics. The prevalence of fistulas varied substantially from 12 to 61% among the 15 clinical centers participating in the study. The prevalence of fistulas exceeded 40% in six centers, ranged between 20 and 40% in six centers, and was less than 20% in three centers. The mean prevalence of fistulas was 45.3% at the four clinical centers in the Northeast, as compared with a mean prevalence of 30.6% in the five clinical centers in the Southeast. Not only did the fistula prevalence vary widely by geographic location, it also varied considerably even among hemodialysis units in a single metropolitan region associated with individual clinical centers (Fig. 1). Thus, for example, among the five hemodialysis units associated with Clinical Center 11, the proportion of study patients with a fistula was 28.6, 43.8, 50.0, 58.8, and 76.7%, respectively.

The likelihood that a fistula was in the upper arm versus the forearm was also examined, after restricting the analysis to those dialysis units that had patients with upper arm fistulas. Overall, 34% of all fistulas were in the upper arm, and 66% were in the forearm. Controlling for dialysis unit, the adjusted odds ratio for having an upper arm versus a forearm fistula was greater in female patients and patients with congestive heart failure (Table 4). Specifically, the proportion of fistulas in the upper arm was 42.9% in women versus 30.1% in men. The proportion of fistulas in the upper arm was 47.2% in patients with congestive heart failure versus 32.6% in patients without heart failure. In contrast, patient age, race, diabetes mellitus, coronary artery disease, tobacco use, peripheral vascular disease, hypertension, obesity, income, education, and duration of dialysis did not correlate with the likelihood of having a fistula in the upper arm rather than the forearm. On stepwise regression analysis, three factors were independently predictive of a higher likelihood of an upper arm fistula: female gender ($P = 0.003$), congestive heart failure ($P = 0.02$), and dialysis unit ($P = 0.005$).

Table 2. Univariate association of fistula use with other factors

		Crude data		Adjusted for HD unit	
	% Fistulas	Odds ratio	95% CI	Odds ratio	95% CI
Gender					
Female	22.4	0.34[b]	(0.27, 0.41)	0.35[b]	(0.28, 0.44)
Male	46.3				
Age					
>65 years	27.8	0.64[b]	(0.52, 0.79)	0.69[a]	(0.55, 0.87)
<65 years	37.5				
Race					
Black	27.7	0.46[b]	(0.38, 0.56)	0.57[b]	(0.44, 0.75)
Non-black	45.5				
BMI					
>27 kg/m^2	26.5	0.59[b]	(0.48, 0.73)	0.56[b]	(0.40, 0.71)
<27 kg/m^2	37.9				
CAD					
Yes	30.4	0.73[b]	(0.58, 0.92)	0.68[a]	(0.52, 0.88)
No	37.5				
CHF					
Yes	33.3	0.93	(0.64, 1.33)	0.89	(0.59, 1.34)
No	35.0				
Diabetes					
Yes	25.4	0.50[b]	(0.41, 0.61)	0.51[a]	(0.41, 0.63)
No	40.7				
Hypertension					
Yes	34.4	0.93	(0.72, 1.22)	1.15	(0.85, 1.56)
No	36.0				
PVD					
Yes	29.2	0.74[a]	(0.54, 0.99)	0.57[a]	(0.40, 0.81)
No	35.9				
Smoking					
Yes	36.5	1.21	(0.99, 1.47)	1.22	(0.99, 1.52)
No	32.3				
Income (per year)					
<$7500	28.6	0.66[b]	(0.53, 0.82)	0.76[a]	(0.59, 0.98)
>$7500	37.9				
Education					
>HS	36.5	1.17	(0.95, 1.44)	1.01	(0.80, 1.28)
≤HS	32.9				
ESRD duration[c]					
<1 year	34.9				
1–5 years	32.9	0.92	(0.73, 1.16)	0.89	(0.69, 1.15)
>5 years	35.4	1.02	(0.78, 1.34)	1.00	(0.74, 1.35)

Abbreviations are: OR, odds ratio of fistulas in the top vs. the bottom category; CAD, coronary artery disease; PVD, peripheral vascular disease; CHF, congestive heart failure; BMI, body mass index; HS, high school.

[a] $P < 0.05$

[b] $P < 0.001$

[c] Statistical comparison for ESRD duration are relative to ESRD < 1 year group

Table 3. Stepwise logistic regression relating fistula use to predictor variables, controlling for dialysis unit[a]

Factor	Adjusted OR	95% CI	*P* value
Female gender	0.37	(0.28, 0.48)	<0.001
PVD	0.55	(0.38, 0.79)	<0.001
Black race	0.64	(0.46, 0.89)	0.008
BMI *per 5 kg/m^2*	0.76	(0.65, 0.87)	<0.001
Age *per 10 years*	0.85	(0.78, 0.94)	<0.001

Abbreviations are: OR, odds ratio; PVD, peripheral vascular disease; and BMI, body mass index.

[a] Dialysis unit was also an independent factor predictive of fistula prevalence ($P < 0.001$)

DISCUSSION

The results of this analysis identify five demographic and clinical factors, each of which was independently associated with a lower likelihood of AV fistulas: female gender, older age, obesity, peripheral vascular disease, and black race. These associations remained statistically significant after adjustment for the hemodialysis unit. Two other multicenter studies have examined the factors influencing the type of vascular access in hemodialysis patients in the United States [12, 17]. Because some of the conclusions differ among the three studies (Table 5), it is important to recognize the methodologic differences among them. Hirth et al analyzed two random samples of hemodialysis patients drawn from the United States Renal Data System (USRDS) [12]. Goodkin et al ana-

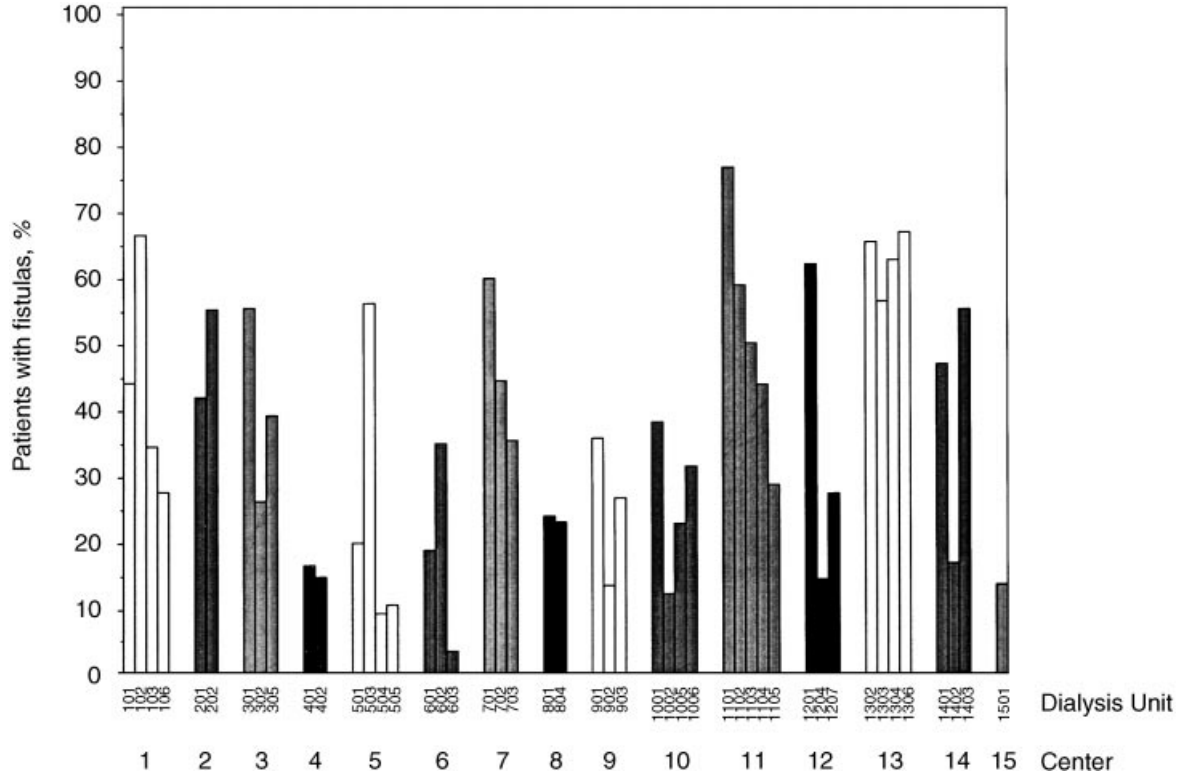

Fig. 1. Frequency of fistula use among the hemodialysis units in the HEMO Study. The dialysis units are sorted with the clinical centers with which they are affiliated. Hemodialysis units enrolling fewer than 15 patients have been excluded.

Table 4. Association of upper arm placement with other factors for patients with fistulas, controlling for dialysis unit[a]

Factor	Odds ratio	95% CI	*P* value
Hypertension	0.89	(0.53, 1.51)	0.67
BMI ≥27 kg/m^2	0.94	(0.60, 1.44)	0.76
Diabetes	0.97	(0.64, 1.46)	0.89
PVD	1.04	(0.53, 1.99)	0.91
CAD	1.11	(0.69, 1.78)	0.68
Black race	1.13	(0.70, 1.82)	0.62
Education >HS	1.18	(0.78, 1.80)	0.44
Smoking	1.25	(0.86, 1.85)	0.25
Age ≥65 years	1.29	(0.83, 1.99)	0.25
Duration ESRD[a]			
>5 years	1.29	(0.75, 2.23)	0.36
1–5 years	1.43	(0.89, 2.34)	0.15
Income ≤$7500/year	1.48	(0.90, 2.41)	0.11
Female gender	1.81	(1.22, 2.70)	0.003
CHF	2.36	(1.11, 5.04)	0.026

This analysis excludes 8 dialysis units for which there were no HEMO Study patients with upper arm fistulas. Abbreviations are: CAD, coronary artery disease; PVD, peripheral vascular disease; CHF, congestive heart failure; BMI, body mass index.

[a] Statistical comparison is relative to patients whose ESRD duration is <1 year

lyzed the vascular access used in a random sample of hemodialysis patients enrolled in the Dialysis Outcomes and Practice Patterns Study (DOPPS) [17]. Both studies reported the vascular access of incident patients (within 30 to 45 days of their first dialysis treatment). In contrast, the current study examined the type of vascular access in the prevalent hemodialysis population. Because the HEMO Study is a clinical trial, we did not attempt to recruit a representative random sample of prevalent patients. To the extent that the selection criteria excluded several types of patients, the conclusions from the present study may not be generalizable to all hemodialysis patients. Moreover, the percentage of fistulas in the present study (34%) was higher than the percentage of fistulas among all hemodialysis patients with permanent vascular accesses (~25%).

The USRDS study classified patients as having an AV fistula or graft, without requiring that the vascular access was actually being used for dialysis. Specifically, "Patients with both a fistula and a temporary dialysis catheter were classified as having a fistula . . . it was presumed that the venous catheter was being used as a temporary access until the graft or fistula matured" [12]. There is no indication of what proportion of fistulas actually matured sufficiently to be used for dialysis. However, other studies have reported that 24% to 53% of fistulas constructed fail to develop adequately to be used for dialysis [8, 18, 19]. Moreover, the likelihood of primary fistula adequacy varies considerably among certain patient subsets, being lower in older patients, diabetics, and obese patients [19]. In the DOPPS Study, only one third of the incident patients had a permanent vascular

Table 5. Association of fistula frequency with clinical factors: A comparison of published studies

	HEMO Study	USRDS [12]	DOPPS [17]	Others
Number of patients	1824	4150	857	106 [6] 200 [7] 92 [13] 88 [14]
Type of patient	Prevalent	Incident	Incident	Incident
Factor associated with lower fistula frequency?				
Female gender	Yes	Yes	Yes	Yes [6, 7, 13, 14]
Older age	Yes	Yes	Yes	Yes [14]
PVD	Yes	Yes	No	Yes [7]
Diabetes	No	Yes	No	No [14]
Obesity	Yes	No	Yes	N/A
Black race	Yes	No	No	N/A
Low income	No	Yes	N/A	N/A
Low education	No	Yes	No	N/A
Geographic location	Yes	Yes	N/A	N/A
HD unit preference	N/A	N/A	Yes	N/A

Abbreviations are: USRDS, United States Renal Data System; DOPPS, Dialysis Outcomes and Practice Patterns Study.

access (fistula or graft) at 45 days after initiation of hemodialysis. Presumably, many of the incident patients with temporary dialysis catheters received a permanent vascular access at a later date. This makes it difficult to extrapolate from factors influencing fistula frequency in the incident population to factors predictive of fistulas in the prevalent dialysis population. The present study evaluated the type of vascular access in use for dialysis in a large, nonrandom, prevalent hemodialysis population.

Notwithstanding these important methodologic differences, all three multicenter studies found a lower frequency of fistulas among women and older patients. Similar observations have been reported from a number of single center studies [6, 7, 13, 14]. Peripheral vascular disease was found to be a significantly associated with a lower fistula rate in the present study and in the USRDS Study. The association was of marginal statistical significance ($P = 0.09$) in the DOPPS study, but was based on analysis of a smaller number of incident patients with a permanent vascular access ($N = 298$). Moreover, one single-center study also has observed a lower frequency of fistulas in patients with peripheral vascular disease [7]. There was a lower frequency of fistulas among diabetics as compared with nondiabetics in the USRDS Study, but not in the DOPPS study or the current investigation. Univariate analysis showed a strong association between diabetes mellitus and a low prevalence of fistulas in the current study (Table 2). However, on multiple regression analysis (Table 3), diabetes mellitus dropped out as an independent predictor of fistula prevalence ($P = 0.10$). The knocking out of diabetes as an independent factor was not due to a single factor, but rather due to the cumulative effect of age, gender, BMI, race, and peripheral vascular disease.

Both the present study and the DOPPS Study found an association between increased BMI and lower fistula rate. The USRDS study found no significant association, but the determination of obesity was less precise (a subjective impression recorded in the medical record, rather than an objective measurement). Because of the selection criteria for the HEMO Study, the effect of BMI on fistula prevalence may have actually been underestimated. To qualify for randomization, the patients had to achieve an equilibrated Kt/V of 1.45 (single-pool Kt/V approximately 1.65) [15]. Among the 79 morbidly obese patients (BMI $\geq$36 kg/m^2), only 21.5% had a fistula.

The frequency of fistulas was lower in black subjects (Table 2), and this difference persisted after adjustment for multiple demographic and clinical factors, including educational level, income, and dialysis unit (Table 3). Moreover, this association was observed in both dialysis units with a high or low proportion of black subjects. In contrast to the findings in the current study, black race was not significantly associated with fistula frequency among incident hemodialysis patients in the USRDS or DOPPS Study. The explanation for the lower prevalence of fistulas in black hemodialysis patients in the current study is not evident; it may be related to racial discrimination or differences in the vasculature between blacks and whites.

Low income was associated with a lower frequency of fistulas on univariate analysis in the present study. However, it was not independently associated with a low fistula prevalence on multiple regression analysis. Income was lower in blacks than nonblacks and lower in females than males; inclusion of race and gender in the multivariate analysis caused income to drop out as an independent factor associated with fistula prevalence. In contrast, the USRDS Study found low income to be independently associated with fistula incidence. In the HEMO Study, income is assessed directly with a patient questionnaire, whereas Hirth et al assessed income indi-

rectly by matching the patient's ZIP code, with ZIP codes associated with >20% poverty levels [12]. The difference in the methodology for determining income between the two studies may account for the differences in their conclusions.

For patients with AV fistulas, the factors that were associated with a higher likelihood of having it in the upper arm were examined (Table 4). Only female gender and presence of heart failure were associated with this finding. A recent study reported that forearm fistulas in female patients had only a 7% likelihood of maturing adequately to be used for dialysis, whereas those in the upper arm had a substantially higher probability (56%) of achieving adequacy [19]. Recognition of the poor likelihood of maturation of forearm fistulas in women may lead vascular surgeons to attempt more fistulas in the upper arm in female dialysis patients.

The USRDS Study highlighted the large variability in fistula placement among different geographic regions in the United States. In 1990, the frequency of fistulas among incident hemodialysis patients varied from a low of 15% in the Southeast to a high of 77% in New England [12]. These regional differences persisted after adjustment for multiple demographic and clinical factors. Similar discrepancies have been reported among the prevalent dialysis population. Thus, in 1997, the prevalence of fistulas varied from a low of 17% in the Southeast to a high of 34% in New England [11]. Although the patients in the HEMO Study are not a random sample of prevalent hemodialysis patients, it is notable that the frequency of fistulas was substantially higher at the clinical centers in the Northeast (45.3%) as compared with those in the Southeast (30.6%). The reason for the large geographic disparities in fistula incidence and prevalence is a subject of ongoing debate, but likely reflects differences in the practice patterns of the nephrologists and vascular surgeons in different regions of the United States. The present study shows that there are large differences in the prevalence of fistulas even among hemodialysis units located in a single metropolitan area (Fig. 1). This finding is consistent with the DOPPS Study, which reported that hemodialysis unit preference was the most significant factor predictive of whether patients received fistulas [17]. Remarkably, the staff in over 35% of 160 random dialysis units in the DOPPS Study preferred grafts to fistulas. The data collected in the HEMO Study do not permit us to determine the reasons for the large variability of fistula prevalence among the hemodialysis units.

In conclusion, a lower likelihood of fistulas in the prevalent dialysis population is associated with both specific subsets of dialysis patients, as well as with the practice patterns at individual dialysis units. Increasing the proportion of fistulas in hemodialysis patients requires focusing on both dialysis units with an overall low prevalence of fistulas, as well as on patient subpopulations with a low prevalence of fistulas. A number of individual dialysis centers have achieved a substantial increase in the frequency of patients with fistulas by increasing their awareness of this issue and implementing a concerted effort to improve outcomes. Three specific approaches that have been used included a special focus on increasing fistula placement in female patients [20], preferential construction of fistulas in the upper arm rather than the forearm [21], and preoperative venous mapping with increased construction of transposition venous fistulas [22, 23].

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